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East Siberian Petroleum Resources

A Research Paper

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East Siberian Petroleum Resources

A Research Paper

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**East Siberian
Petroleum Resources****Key Judgments**

*Information available
as of 31 July 1984
was used in this report.*

Reserve limitations in existing oil-producing areas could begin to constrain Soviet oil production by the early 1990s. To offset this potential problem, the Soviets have begun to search for petroleum resources in new areas. In the areas being examined, exploration of East Siberia is furthest along.¹ Limited funding, severe environmental conditions, and a lack of infrastructure and equipment, however, have slowed the petroleum development activities in even that area. On the basis of our analysis of the complex geology of the East Siberian petroleum reservoirs, we believe that the Soviets have located and drilled reservoirs containing between 500 million and 1 billion barrels of proved oil reserves—at most only about 2 percent of the estimated proved reserves.

In our judgment, the geology of the region strongly weighs against the possibility that the Soviets will discover the giant fields necessary to warrant a major development effort. When arrayed against the distance to industrialized regions, the complexity of the petroleum reservoirs, and the quantity of oil, it is doubtful that it would be cost effective in the near term to concentrate on the development of the petroleum resources of East Siberia even if substantial oil discoveries were found. In view of this assessment, we expect:

- Little increase in oil exploration in East Siberia in the near term.
- Stronger Soviet efforts in exploration of offshore areas, especially the Barents Sea.
- Development of lower quality oil reservoirs in less remote areas through the use of enhanced oil recovery techniques.

The poor prospects for major oil discoveries in East Siberia, coupled with stagnant output in West Siberia, further increase the likelihood of a decline in Soviet oil production during the 1990s. Given the seven- to 10-year leadtime involved in bringing new oil deposits into commercial production—even in the unlikely event that major discoveries are made in East Siberia—the production would not have much impact until the mid-1990s at the earliest.

¹ For the purposes of this report, East Siberia refers only to that part of the region known in geological terms as the East Siberian platform.

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East Siberian Petroleum Resources

Background

The growth that has characterized Soviet oil production since the 1940s has been slowed by production declines in the European oilfields and diminishing growth in West Siberia (figure 1). Production plateaued at about 12.4 million barrels per day (b/d) in October 1982, and in 1983 West Siberia—which accounts for 60 percent of national oil output—for the first time failed to meet planned production goals. Operational problems and adverse weather were largely responsible for the production shortfall. Unless new oil discoveries are made, reserve limitations in West Siberia could increasingly constrain production, possibly as soon as the early 1990s.

In the past, the Soviets have been able to maintain growth in oil production by finding and developing large new oil provinces—Urals-Volga in the 1950s and West Siberia in the 1960s and 1970s. Spurred by expected declines in the West Siberian reserves later this decade, the Soviets are examining the petroleum potential of several new areas—the Barents, Kara, and Sakhalin offshore areas, and onshore in East Siberia. The exploration in East Siberia is furthest along. Some Soviet geologists claim the region contains more oil than West Siberia, but their claim is not substantiated by geological data. Moreover, development of any of these areas would entail an enormous commitment of investment and manpower at a time when the Soviets are short of both.

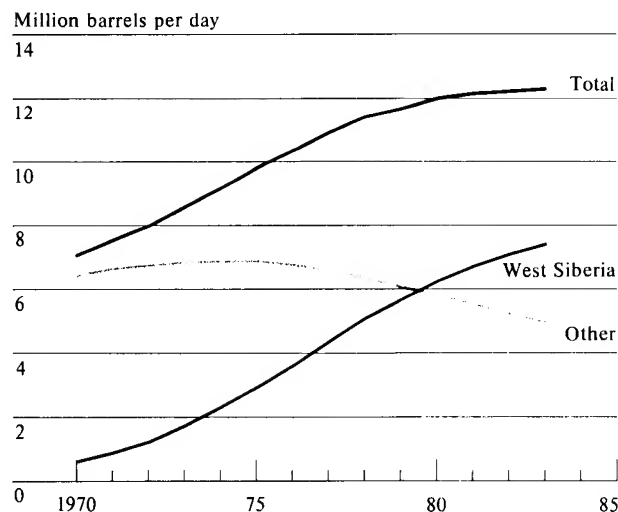
Geologic and Geographic Setting

The East Siberian platform²—the heart of the region's petroleum potential—is a vast plateau located between the Lena and Yenisey Rivers (figure 2). At 3.5 million square kilometers, it is one of the largest platforms in the world and is mostly unexplored. Preliminary data indicate that it contains some of the world's oldest petroleum reservoirs. The oil-bearing potential of ancient reservoirs is a subject of debate among petroleum geologists in the USSR and in other countries where similar reservoirs exist.³ Most West-

² A platform is that part of a continent covered by flat or gently tilted sedimentary strata.

³ In geological terms these deposits date from the Proterozoic and early Cambrian age.

Figure 1
USSR: Regional Oil Production,
1970-83



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ern geologists tend to discount their petroleum potential, but Soviet experience in East Siberia as well as discoveries in Australia and China indicate that petroleum deposits are possible.

Exploration and Development

The Soviets have been exploring the petroleum potential of East Siberia since the early 1900s, when they drilled four unsuccessful shallow exploration wells on the shores of Lake Baikal. By the end of the 1930s, large-scale mapping and shallow drilling were accomplished along the periphery of the East Siberian platform. By the mid-1950s, the first strong flow of gas and condensate from a well in the Ust-Vilyuy area established the promise of the lower Vilyuy River region. The concentration of exploration in that area, however, caused the Soviets to neglect the rest of East Siberia.

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Figure 2
The East Siberian Platform



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Exploration in East Siberia continued in the 1960s when the Markovo oil and gas field was discovered. Although four commercial oilfields have since been developed—Danilov, Verkhnechon, Dulismin, and Markovo—the success rate, or ratio of drilling to actual oil finds, has been disappointing, especially compared with the West Siberian basin. Moreover, most of the discoveries in East Siberia have been gas and gas condensate.

Results from exploration in 1981-82 revived hope for the development of large-scale production in East Siberia. Oil flows were obtained from the Tasyur-yakh, Verkhnevilyuchan, and Vilyuy-Dzherbin fields, and numerous traces of oil were observed in the Ozern and Toynokh fields. The Danilov field, discovered in

1981, yielded 2,450 b/d from three wells, and one well in the Verkhnechon field produced 2,200 b/d. The quality of East Siberian oil and condensate is highly correlated with the age of the reservoirs. Oil in the older Proterozoic and Cambrian reservoirs is generally a light crude with a low sulfur content, comparable to Saudi light oil (tables 1 and 2). Heavier crudes with higher sulfur, comparable to some Mexican heavy crudes, are generally found in the younger deposits.

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East Siberian Geology

About 550 million years ago, a barrier reef covered by a shallow sea extended across the East Siberian platform. Petroleum source beds lay below the reef, and salt and other sediments accumulated in vast lagoons within the reef area. The salt acts as the primary seal for the oil and gas pools in the Lena-Tunguska province in the southwest part of the East Siberian region. The reservoirs themselves are Cambrian limestones and older sandstones (appendix B).

The other petroleum-bearing province in East Siberia is in the Khatanga-Vilyuy region. The deposits of this region are much younger than those in the Lena-Tunguska region, dating from the Paleozoic and Mesozoic ages. Oil and gas pools in the Khatanga-Vilyuy region occur as small anticlines (domes)—also called structural traps—formed by the uplift of the strata. This uplift is probably responsible for the predominance of gasfields in this region. Such an uplift reduces the pressure in the reservoir, causing gas to come out of solution and rise to the higher part of the structures.

In contrast to West Siberia, where petroleum traps are structural and relatively unfaulted, East Siberia contains mostly stratigraphic traps, complicated by faulting and a lack of continuity of sedimentation (figure 3). The presence of stratigraphic traps requires

more intense application of geophysical exploration techniques and extensive drilling programs usually not required for delineation of structural traps. At a minimum, because of its discontinuous shape, far more drilling should be required to measure the size of a stratigraphic trap than a structural trap. The drilling requirements alone would place an added strain on already taut Soviet investment and manpower. Moreover, given the complexity of stratigraphic traps, the Soviets could not be as certain about the amount of recoverable oil as would be the case when developing structural traps.

The platform is some 3,000 kilometers east of Moscow, far from the major industrial and population centers of European Russia. With the possible exception of Antarctica, the climate of East Siberia is the worst in the world. The economic activity that does exist in the region, including oil exploration, is concentrated along the rivers, the area's main transportation arteries. Population density is only one person per square kilometer. Although the Soviets have emphasized the need to develop the natural resources of remote regions of the country, including East Siberia, the region has been given only a small share of total investment allocations. Despite a lack of precise data, we can say that, given the complicated geology, the infrastructure requirements, and severe climate, costs of petroleum production in East Siberia probably would be about the highest in the USSR.

Despite these limited successes, shortages of seismic and drilling equipment have retarded Soviet drilling efforts in East Siberia. Drilling density is only one well per 3,200 square kilometers, compared with one well per 12 square kilometers in the middle Ob' region of West Siberia. The distribution of drilling in East Siberia is uneven and heavily concentrated in areas near previous discoveries. Extrapolating from past trends, we project that between 800,000 and 900,000 meters will be drilled in East Siberia between 1980 and 1985, roughly 3 percent of planned drilling nationwide.

The Reserve Base

The size and quality of reserves will ultimately determine Soviet development of the East Siberian platform and its contribution to future Soviet oil production.⁴ The Soviets have already demonstrated in West Siberia that they will develop remote areas if the quality and quantity of oil justify the enormous

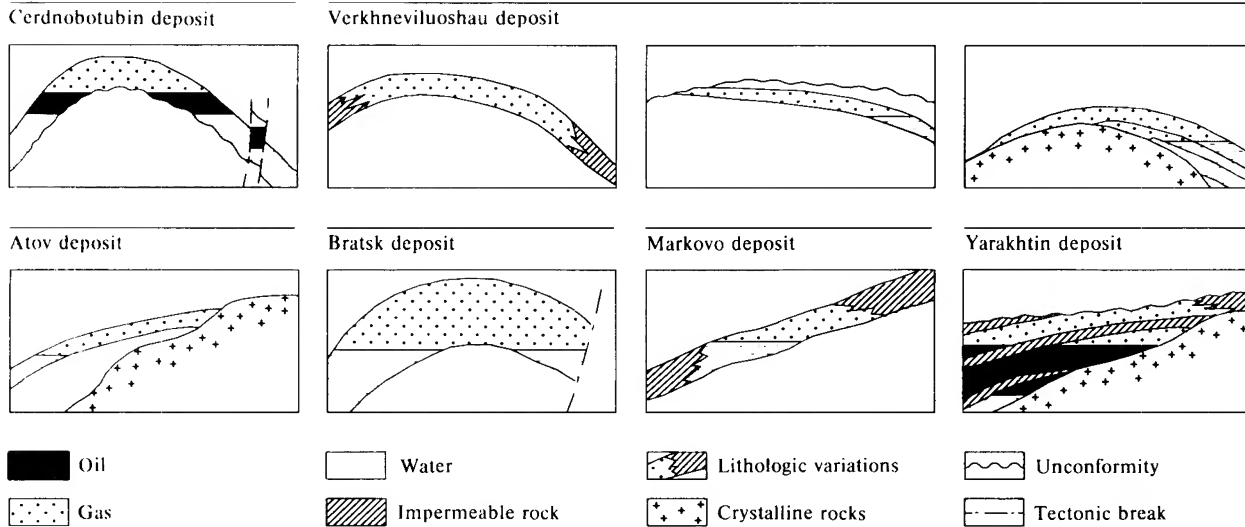
⁴ The term quality as applied to Soviet reserves refers to the characteristics of the oil—density, viscosity, and chemical composition—and of the reservoirs—size, depth, porosity, permeability, temperature, and pressure—which determine the speed, ease, and cost of oil extraction.

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Figure 3
East Siberia: Types of Oil and Gas Traps



Source: *Geology of Oil and Gas in the Siberian Platform*; Kontrovich, Surkova, and Trafimuk; Moscow, "NEDRA" 1981.

investment. On the basis of our geologic analysis of East Siberia, we estimate that the Soviets have located and drilled wells in reservoirs containing between 500 million and 1 billion barrels of proved oil reserves. This amount represents at most 2 percent of estimated Soviet reserves and is sufficient to support only 40 to 80 days of national production at the current rate of output. Moscow has also delineated areas containing an estimated 3-11 billion barrels of potential reserves—amounts that can be regarded only as speculative at this phase. Of the few estimates available on the East Siberian petroleum potential, our estimate of proved and potential reserves is lower than those of the US Geological Survey (USGS)

Our geological analysis indicates that the quality of East Siberian oil reservoirs is much worse than that of the reservoirs in West Siberia. The reservoirs in East Siberia are deep, averaging about 2,800 meters (with some as deep as 4,000 meters), compared with an average depth of 2,200 meters in West Siberia. Moreover, the reservoirs are characterized by extremely low porosity and permeability,⁶ thereby reducing well flow rates and raising drilling requirements (table 1)

⁶ We have not made an estimate of natural gas reserves in East Siberia. Other US agencies place conventionally recoverable gas resources in a range between 72 and 278 trillion cubic feet (tcf) with 158 tcf as a mean gas reserve base. In addition, gas-hydrate deposits in the northern permafrost area are estimated to contain possibly 27 tcf of recoverable gas

⁶ Porosity is the percentage of rock bulk volume occupied by open or pore space in which oil can accumulate. Permeability is a measure of ease with which fluids move through pore space.

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Table 1
East Siberia: Physical Characteristics of Proterozoic and Lower
Cambrian Petroleum-Bearing Horizons

Age	Suite	Productive Horizon (Lithology)	Thickness (meters)	Porosity (percent)	Permeability (millidarcys)
Early Cambrian	Angara	Kelorskiy (carbonate)	16 to 30	1.4 to 7.0	0 to 185
		Bil'chir (carbonate)	60 to 120	0.5 to 11.0	0 to 24
	Bulay	Birkin (carbonate)	90 to 100	0.06 to 1.0	0 to 253
	Bel'ya	Atovo (carbonate)	60 to 90	0.3 to 16.0	0 to 24
		Khristovorova (carbonate)	50 to 64	0.5 to 1.5	0 to 100
	Usol'ye	Balykhtin (carbonate)	9 to 10	0.6 to 8.0	Fractures up to 10
		Osa (carbonate)	15 to 100	0.1 to 25.0	Up to 163
	Moty	Ust'-kut (carbonate)	Up to 90	0.7 to 12.0	0 to 36
		Early Cambrian to Vendian	Preobrazhenka (carbonate)	17	0.3 to 12.0
	Verkhnetarsk (sandstone)		2 to 14	3.0 to 19.0	0.5 to 77
Vendian (Proterozoic)		Parfenovo (sandstone)	15 to 90	8 to 23	Up to 4,300
		Yaraktin (sandstone)	Up to 30	0.2 to 17.5	Up to 4,000
		Markovo (sandstone)	Up to 30	2 to 13	Up to 20
		Bezymyanny (sandstone and conglomerate)	Up to 24	4 to 6	0.8 to 3.0

East Siberia in the Years Ahead

In our judgment, the distance from the economic heartland and the extreme environment will cause the Soviets to defer any major exploration of East Siberia at least through the 1980s. Total drilling in the area may increase to about 1 million meters during the next five-year plan, which would still represent only a minor increase and a small fraction of the total Soviet drilling effort during that period (figure 5).

Our geologic evaluation of the areas that the Soviets are targeting indicates that these reserve additions will not be large. Most of the petroleum in East Siberia is in fractured carbonate reservoirs formed by stratigraphic trapping and faulting, making them very

difficult to locate and requiring the use of sophisticated geophysical equipment and techniques. Unless the Soviets acquire such equipment, especially the specialized seismic gear,⁷ success in locating East Siberian traps is not likely to improve over the currently used "hit-or-miss" approach.

The geology of East Siberia strongly weighs against the possibility that the Soviets will discover the large fields necessary to trigger a major development effort.

⁷ The Soviets will need to procure Western seismic equipment that is capable of delineating complicated stratigraphic traps, such as common-depth-point reflection seismic gear, computers, and software to process the data.

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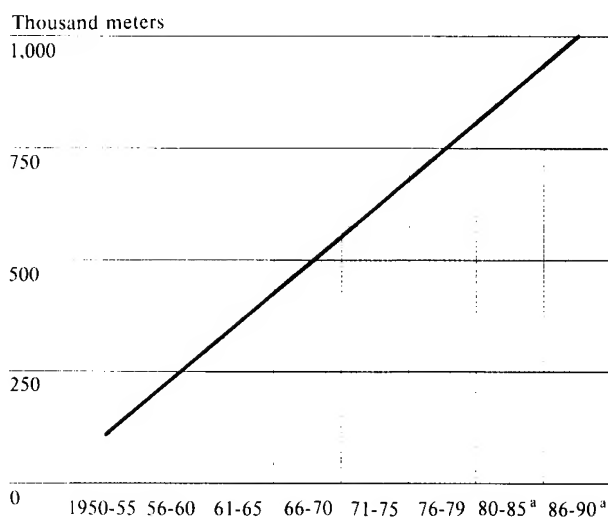
Table 2
East Siberia: Oil and Condensate Characteristics

Field	Depth (meters)	Reservoir	Choke (millimeters)	Oil (barrels per day)	Condensate (barrels per day)	Gas (million cubic feet per day)	Condensate/ Gas Ratio	Gas/Oil Ratio	Specific Gravity of Oil	Specific Gravity of Condensate	Sulfur Content (percent)	Formation Pressure (kilograms per square centimeter)	Temperature (°C)
Markovo	2,156-2,164	Osa	75	6,700		17,500		350	0.815		0.8	268	33
	2,156-2,164	Osa	25	2,040					0.815		0.8	268	33
	2,156-2,164	Osa	16	1,441					0.815		0.8	268	33
	2,172	Osa	16	318				215	0.818		0.74	271	33
		Parfenovo	75			8,445	560			0.713-0.764	0.02		34
	2,574-2,605	Markovo	25		549	8,655							
	2,900	Bezmyanny	75			35							
Bil'chir	2,700-2,750	Bil'chir				2,625-3,500						28	
Birkin	1,236	Birkin				15,750						120	
Krivoluka	2,527-2,560	Parfenovo	16	271				400	0.814		0.07	284	
Khristoforova	912	Bil'chir	22			7,000							
Sredne-Botubin	1,500	Osa				7,700						142	
	1,880	Parfenovo				9,275-14,350						147	
Preobrazhenka	1,690	Middle Moty (Preobrazhenka)				2,170						153	
Kuyumba	2,170	Middle Moty (dolomite)	11.3			2,520	70						
	2,170	Various				7,000-14,000							

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Figure 5
East Siberian Drilling, 1950-90



^a Projected.

On a worldwide basis, 82 percent of the 300 giant oil and gas fields discovered has had no major sedimentation discontinuities or faulting in their cross sections. The prevalence of such unconformities throughout the petroleum-bearing areas of East Siberia greatly lowers the odds that the Soviets will find fields comparable to Romashkino or Samotlor, which stimulated the rapid development of the Urals-Volga and West Siberia, respectively.

The low probability of major oil discoveries in East Siberia is further supported by the low production of analogous reservoirs in the Amadeus basin in Australia and the Tientsin area in China. Although oil discoveries have been reported in these regions, the reserves are relatively small. In addition, the geological similarity between the East Siberian stratigraphic section and "sub-salt" areas of the Northwest Territories in Canada suggests that the area is probably gas prone. Exploration in the Canadian areas has yielded gas to oil reserves in a ratio of more than 2,000:1. Even if the Soviets find a giant oil or gas field in East Siberia, the cost of development of such fields will

probably be prohibitive, at least in the near term. We believe any development of production capacity in this decade, and probably the next, would be limited to small amounts for local use.

Although existing evidence indicates that development of the East Siberian reserve base may not be economical, further exploration could improve the prospects. According to unclassified Soviet literature, Moscow has stated its determination to search for new and larger petroleum deposits in the area. We believe exploration in East Siberia will be largely driven by academic and scientific interest in the unique reservoirs and reluctance to abandon a virgin area in the face of declining prospects in older regions. This effort is likely to result in the addition of increments to the reserve base into the 1990s.

Implications for Soviet Oil Production and Western Imports

The lackluster results of the exploration work in East Siberia is probably no surprise to the Soviets. Despite some optimistic remarks in the press and scientific literature, Soviet long-range planning indicates little expectation of much production in East Siberia in the near term. This will force the Soviets to look elsewhere to find another petroleum province and to make greater efforts to hold production as high as possible in producing regions. To do either, the Soviets will need to step up imports of Western (largely US) petroleum production equipment and technology.

Geologically, the Barents Sea is the most likely candidate for petroleum discoveries, and exploration suggests that the Soviets have come to the same conclusion. Locating and developing these deposits will increase the need for sophisticated equipment and know-how, especially as operations move into deeper waters. Some of this equipment is subject to trade controls, however, because of its potential military application.

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For onshore deposits, the Soviets are counting on Western enhanced oil recovery (EOR) technology to increase the recovery from older fields and to produce underdeveloped fields that contain heavy oil. In the past six years, the Soviets have spent more than \$60 million to acquire EOR equipment, chemicals, and plants largely from the United States, Italy, and Japan. We expect that they will continue to purchase large amounts of EOR technology, much of which will probably be earmarked for use in West Siberia. We also anticipate that the Soviets will continue importing other types of Western equipment and technology, such as submersible pumps, drill pipe, and gaslift equipment

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The poor prospects for major oil discoveries in East Siberia, coupled with stagnant production in West Siberia, increase the likelihood of a decline in Soviet oil production during the 1990s. Whether Moscow is willing to commit the resources required to achieve any further increase in oil production or to spend hard currency to import Western technology will depend on how quickly West Siberian reserves begin to constrain production. In any event, we expect the Soviets to push development of lower quality fields and reservoirs in less remote areas where infrastructure is already in place

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Appendix B

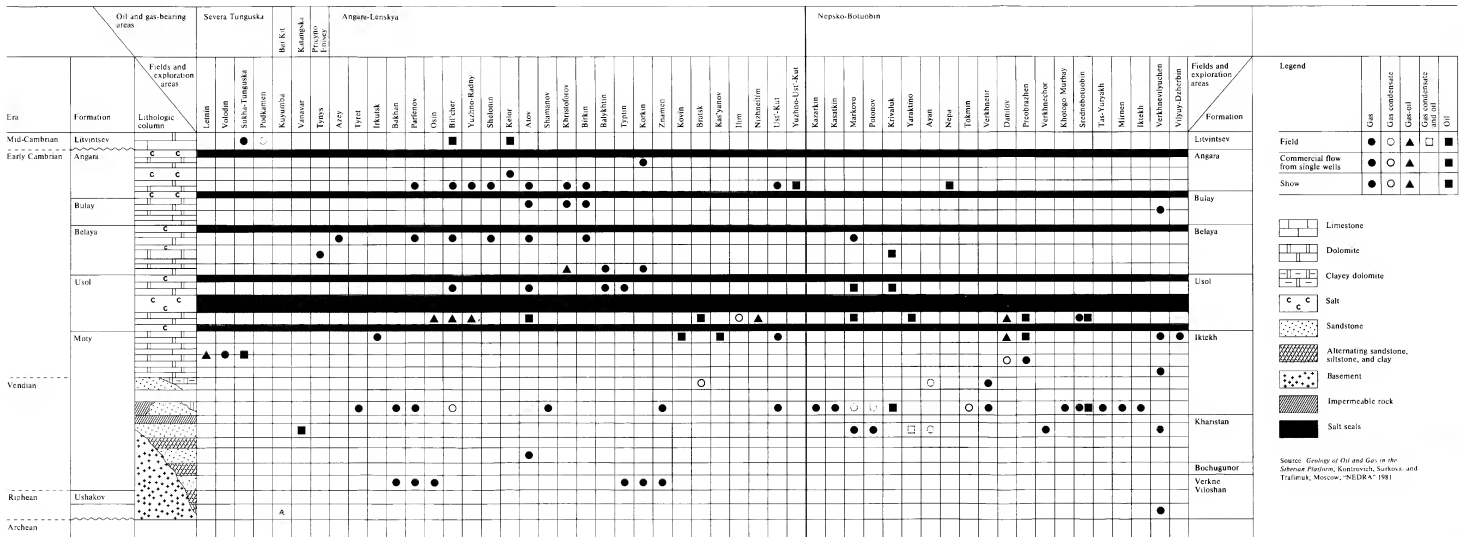
East Siberian Platform: Distribution of Oil and Gas in Selected Areas

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Figure B-1
Angara-Lensky, Nepsko-Botuobin, Severa Tunguska,
Bai Kit, Katangsk, and Pricyno Enisey

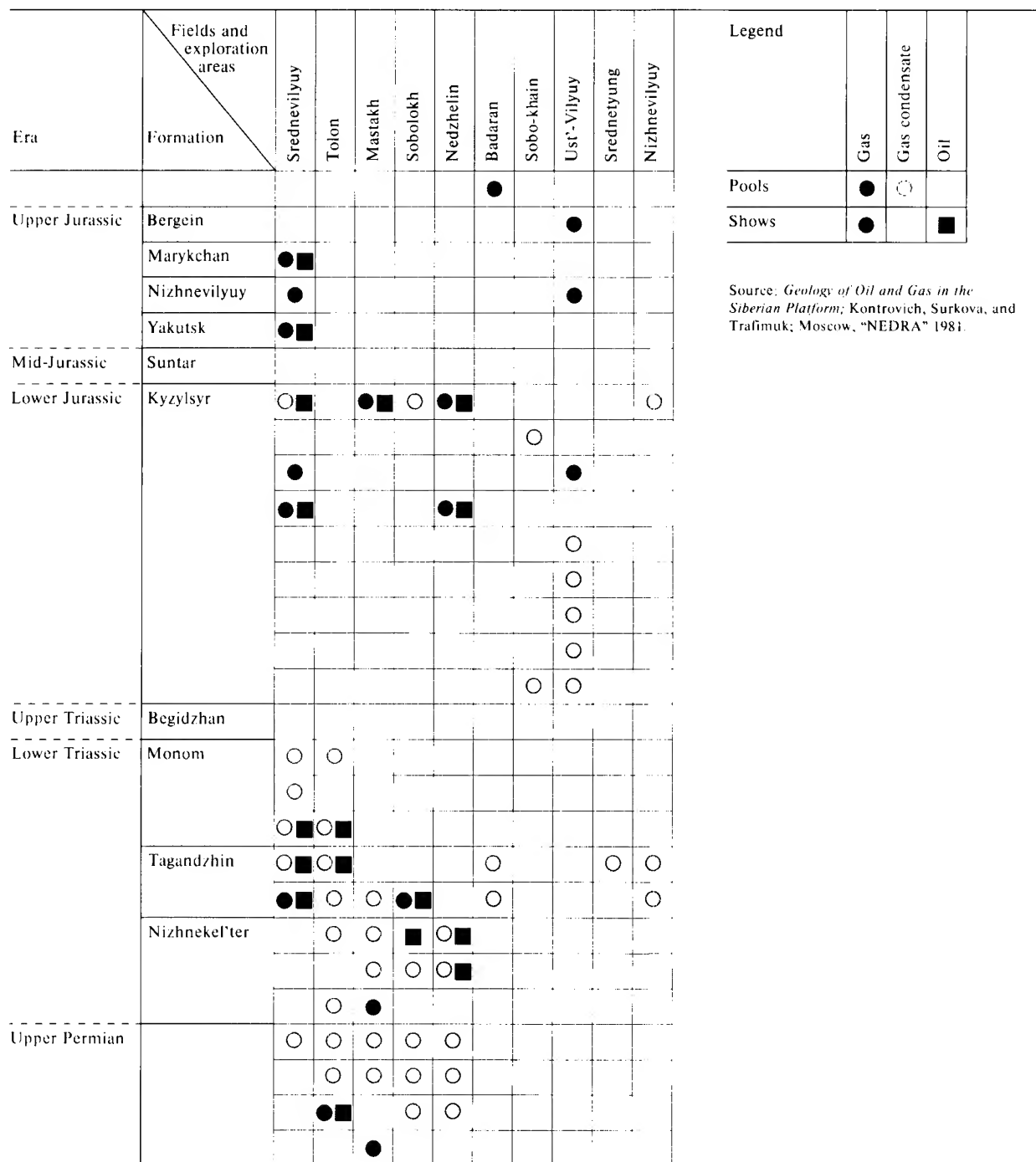


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Figure B-2
Vilyuy and Cis-Verkhoyansk



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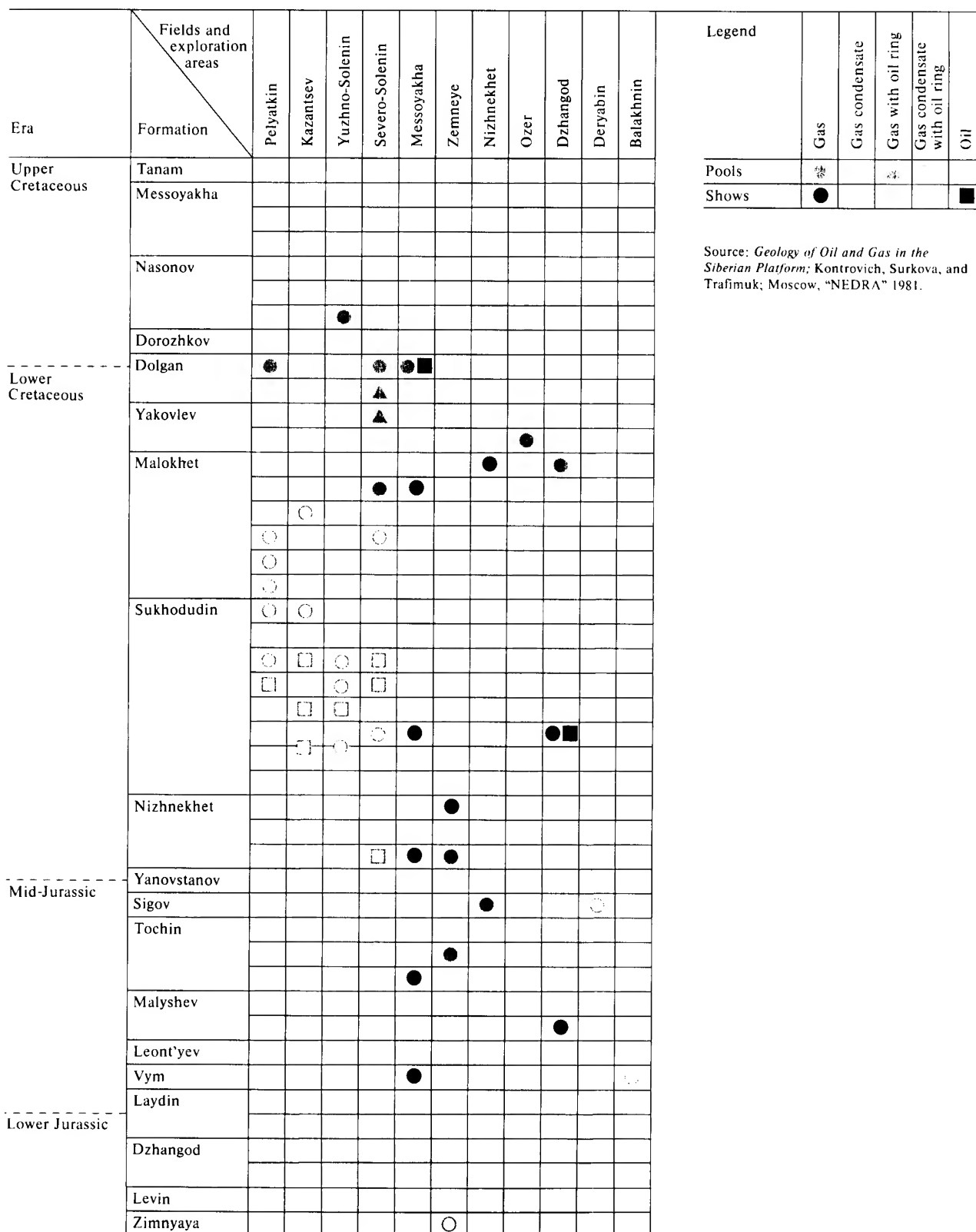
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Figure B-3
Yenisey-Khatanga



Legend

	Gas	Gas condensate	Gas with oil ring	Gas condensate with oil ring	Oil
Pools	●		●		
Shows	●				■

Source: *Geology of Oil and Gas in the Siberian Platform*; Kontrovich, Surkova, and Trafimuk; Moscow, "NEDRA" 1981.

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